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Introductory Lecture to the Course of Chemistry, Delivered in Jefferson Medical College, November 6, 1844.

Franklin Bache, MD

INTRODUCTORY LECTURE

TO THE

COURSE OF CHEMISTRY,

DELIVERED IN

JEFFERSON MEDICAL COLLEGE,

NOVEMBER 6, 1844,

BY

FRANKLIN BACHE, M.D.

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Philadelphia, Nov. 15, 1844.

PROF. FRANKLIN BACHE,

Dear Sir;

At a meeting of the Students of Jefferson Medical College, on Tuesday the 12th inst., J. P. Andrews, of Pa., President, and A. H. Hoff, of N. Y., Secretary, the following gentlemen were appointed a committee to represent the Class in soliciting for publication, with sentiments of regard and esteem, your lecture, introductory to the Course on Chemistry.

J. M. RUFFIN, Miss.
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H. C. BICKFORD, N. H.
E. C. DYER, Mass.
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R. SUTHERLAND, N. Scotia,
J. C. NEVES, S. America,
EUGENE BILLON, France.

H. R. BRANHAM, Geo., *Sec'ry. of Com.*

Philadelphia, Nov. 19, 1844.

GENTLEMEN,

I yesterday received your note, requesting, in behalf of the Class, a copy of my introductory lecture for publication. It gives me much pleasure to comply with this request, and, accordingly, I place the manuscript at your disposal.

I am, Gentlemen,

Very sincerely yours,

FRANKLIN BACHE.

To Messrs. J. M. Ruffin, S. R. Philbrick, and others, Committee of the Class of Jefferson Medical College.

INTRODUCTORY.

It is with no ordinary feelings, gentlemen, that I receive your greetings; I assure you that I reciprocate them with the utmost cordiality. You have come from various, and some of you from distant parts of our extensive country, to pursue your professional studies in our city, the metropolis of medical science in America. To my former pupils, I offer my right hand in token of regard, and in remembrance of our relations in former years; and to you all I tender a hearty welcome, accompanied by a wish that your sojourn amongst us may prove agreeable in a social point of view, and be attended with ample fruits of medical attainment.

It is not necessary at the present day to dwell on the importance of science. The benefits which it confers, are seen and felt by every one. At this enlightened period, we are not willing to accept the definition, by the author of the Wealth of Nations, that a philosopher is a person whose trade is to do nothing, and to speculate in every thing. Public opinion is fully in favor of the investigation of the laws of nature, and is not disposed to make distinctions between researches which have an immediate practical bearing, and those in regard to which such bearing is not obvious. At present there are fewer of those croakers than formerly, who are constantly addressing to the student of nature, the humiliating question, *cui bono;* just as if the calming and ennobling influence of philosophy were not, of itself, a sufficient reward to stimulate the exertions of those who engage in the investigation of nature.

The ancient philosophers made no solid progress in the study of nature; because they indulged in vain speculation, instead of pursuing the path of observation and experiment. For nearly eighteen centuries, their absurd dogmas and wild theories held their sway; and the consequent darkness was not dispelled, until the appearance of Galileo in Italy, and Bacon in England. Galileo set a noble example of resistance to superstition and prejudice, and of the cultivation of science in the experimental path; and Bacon gave us a code of laws, to direct us in the best mode of interrogating nature.

Science is knowledge reduced to a system. Its foundations are observation, experiment, and analogy. By observation we are made acquainted with the facts spontaneously presented by nature; by experiment we place matter in artificial relations, and discover new facts; and by analogy we are enabled to connect those facts which have a similar bearing. Analogies are afterwards perceived between groups of analogous facts; and, by ascending in this way to higher and higher steps of generalization, knowledge comes at last to be reduced to a system, when it constitutes science. When we observe, we allow nature to give her own evidence; when we experiment, we interrogate, nay more, we cross-examine her, in order to make her tell the truth. But we must go still further; we must sift her testimony, separate the essential from the accidental facts, estimate the comparative value of evidence, apparently contradictory, and finally draw from the whole a true verdict. If, after all, we cannot come to a satisfactory decision, we must give nature a new trial, and make her answer new questions, in order, if possible, to elicit the truth.

Theory is a supposition assumed to be true, but not proved to be so, which connects the facts of a science or branch of science in a natural order, and explains them in a more or less perfect manner. Thus, the supposition that vision depends upon vibrations in a peculiar luminiferous medium, forms the wave-theory of light. The assumption of the circulation of electric currents in one direction around the particles of magnets, forms Ampère's beautiful theory of magnetism; and the hypothesis that the laws of combination depend upon the union of ultimate particles having different weights, constitutes the atomic theory of Dalton. Theories are formed, principally, in two ways. Sometimes a great mind penetrates, as it were by intuition, the secrets of nature, and makes, in relation to some point in science, a sagacious conjecture, which afterwards assumes the consistency of a theory, when facts, subsequently ascertained, derived from observation and experiment, are found to correspond with it. These remarks will apply to the wave-theory of light. It was Huyghens who first made the conjecture that light is propagated by undulations; but his opinion was overborne by that of Newton, who adopted the emission theory. It was reserved for Young, a philosopher of the first order, whose reputation has been gaining every day since his death, to give to the conjecture of Huyghens, the force of one of the most perfect theories that now adorn science. By a test experiment, in relation to the black and white stripes, formed within the shadows of bodies by the inflexion of light, he showed that the black ones are produced by the meeting of two rays, passing one on each side of the inflecting body. Now, on the emission theory, two rays, falling together, cannot produce darkness; but, on the wave-theory, two undulations may destroy each other, provided they are of equal force and in contrary directions, which may happen when the rays exhibit a certain minute difference in the length of their paths. The production of darkness by the mutual influence of two rays, forms a case of what is called the *interference of light*. Subsequently it was found, that the phenomena of polarization could only be explained in a satisfactory manner, by the aid of the wave-theory. The other principal way in which theories are formed, is to adapt a supposition to a number of facts previously observed, so as to connect them in a convenient and satisfactory manner. In this way, the magnetic theory of Ampère, and the atomic theory of Dalton were formed. Theories are strengthened, and rendered more and more perfect, if new facts, as they are successively observed, coincide with them; but a single contradictory fact, well ascertained, renders them untenable, unless in some modified form.

Theories are exceedingly useful in science, provided they are kept in strict subordination to observation and experiment. But we must carefully guard against considering them as a perfect system of knowledge, based upon fundamental laws. They may be compared to a scaffolding, by means of which we are enabled to build up the edifice of science, and which, after having served its temporary purpose, must be removed.

My duty in the professorship which I have the honor to hold in this College, is to teach chemistry in its application to medicine. In order to fulfil this duty, it is necessary that I should present a general view of the science, and of the fundamental laws which govern its phenomena. After having acquired this preliminary knowledge, the student is prepared to understand the applications to medicine.

While mechanical philosophy notices the mutual action of masses of matter, operating at sensible distances, chemistry, on the other hand, takes cognizance of the reciprocal action of its smallest parts, acting at distances too minute to be measured. Thus, chemistry is the science which has for its object, the study of the intimate nature of matter. When we reflect that we are surrounded by matter; that, indeed, we are constantly enveloped by an invisible medium in the form of atmospheric air, which we unceasingly draw into our lungs, as the indispensable condition of life; that our bodies, our food, and our medicines consist of material particles—we cannot fail to be sensible that the science which treats of matter, so as to make us acquainted with its intimate qualities, must be one of the most practically useful that can engage the attention of man.

It is hardly necessary to dwell upon the useful applications of chemistry to the arts. Indeed, it is impossible to enumerate them all within the limits of a single discourse. Bleaching, dyeing, glassmaking, the working of metals, are all chemical arts. Reflect for one moment on the useful applications of glass. What would astronomy be without it? What, indeed, would chemistry itself have been without its invaluable aid. It is no exaggeration to assert, that, without glass, chemistry, as a science, would still have been in its infancy. Again, suppose that chemistry had not taught man the art of metallurgy, could our race have emerged from barbarism? It has been truly said, that the extent and variety of the iron manufactures of a nation are an index of its progress in civilization. We may mention the manufacture of gas for illumination, as one of the chemical arts of great utility. It is true that it is distributed by means of mechanical contrivances; but its production and purification are strictly chemical processes. It forms the best and cheapest light we can use, and is applicable, to a certain extent, to the cooking of our food. The steam engine is a mechanical contrivance, but the moving power is a chemical agent, steam. The mode of forming steam, the state in which heat exists in it, the law of its expansion when formed in contact with water—are all subjects of chemical inquiry, which have been ably and successfully investigated by Black and Watt. This wonderful machine has made a vast revolution in our social condition, which our limits will not permit us to trace, and forms, next to the art of printing, the greatest invention that has blessed mankind.

Chemists are accustomed to distinguish two kinds of matter. One kind is exceedingly subtile, not confinable, probably spread throughout universal space, and having particles which are endowed with self-repulsion. Not being obedient to the law of gravitation, this kind of matter is called *imponderable*. The other kind embraces all the gross forms of matter, those forms which are universally recognized as material, and of which the most prominent property is the possession of weight. This kind of matter is, therefore, called *ponderable*.

Imponderable matter is of four different kinds, light, heat, electricity and magnetism. Light, as a subject of study, belongs to natural philosophy; yet it is an influential agent in many chemical operations. Heat is always treated of as a part of chemistry, and forms a most important subject of study to the physician. It is to heat we owe the liquid and aëriform states of ponderable matter. Its intimate connection with the phenommena of life is familiar to every one. It is impossible to understand physiology, without a respectable knowledge of *thermotics*, or the science of caloric. The discussions which arise in treating of animal heat, for example, would be utterly unintelligible to a student, not well grounded in the laws which govern the absorption, extrication, and distribution of heat. The same knowledge is necessary to enable him to understand the pathological states of inflammation and fever, in which an undue extrication of heat is the chief phenomenon. I shall treat of electricity under the two heads of common electricity, and galvanic electricity or galvanism. The study of this imponderable is necessary in a chemical course, on account of its influence in determining combination and decomposition, and of its importance as the basis of chemical classification. It is also deserving of study as a therapeutic agent; and it is matter of regret, that it is too much neglected in this relation; perhaps because its use has fallen, for the most part, into empirical and imcompetent hands. Magnetism will next be noticed, the account of which, and of its close connexion with electricity, will finish the imponderables.

In reflecting upon the imponderable principles as a group, it is impossible not to be struck with the numerous analogies which they present. The wave-theory, as applied to light, rendered probable by the sagacious experiments of Young on interference, and established by Fresnel and others as the only competent assumption in explanation of the intricate phenomena of polarization, seems destined to be applied to heat also, now that the polarization of this imponderable has been fully established by Forbes. These views, taken in connexion with the facts, that light is often accompanied by heat, and that a certain intensity of heat always produces light, lead to the conjecture that the phenomena of light and heat may possibly depend, not upon waves of two different media, but upon waves of one and the same medium, capable of impressing us differently from differences in their length, velocity, and amplitude of excursion. Again, it is found that the connexion between electricity and magnetism is so close, that the conclusion is almost irresistible that they constitute one principle. Thus a current of electricity develops magnetism, and, conversely, a current of magnetism excites electricity. The phenomena, in each of these cases, are classed as separate branches of science ; in the former case as *electro-magnetism ;* in the latter, as *magneto-electricity.* Lastly, it may be mentioned that heat and electricity are closely connected. It has always been known that electricity excites heat; but it was reserved for Seebeck, of Berlin, to show that heat might be made to excite electricity. The phenomena, in the latter case, form the branch of science; called *thermo-electricity.* The discovery of Seebeck has led to the invention of an instrument, called the *thermo-multiplier*, which far exceeds the thermometer in delicacy, and by means of which the important discoveries of Melloni, on the transmissibility of heat through different media, were made.

Having finished the imponderable bodies, I shall next call your attention to those which have weight. But before entering upon these individually, it will be necessary to discuss the subjects of chemical attraction, the laws of combination, the atomic theory, the use of chemical symbols, the pressure of the atmosphere, and specific gravity. These topics involve general principles, or else considerations more or less applicable to all the ponderable bodies ; and their discussion forms a fit preparation for comprehending the details which are to follow, when the individual ponderable bodies are treated of.

Ponderable bodies are conveniently divided into non-metallic and metallic. The non-metallic class embraces thirteen members; namely, oxygen, hydrogen, nitrogen, sulphur, selenium, phosphorus, chlorine, iodine, bromine, fluorine, carbon, boron, and silicon. These bodies present examples of the three states of aggregation, some being gaseous, others solid, and one liquid. They are electro-negative, when compared with the large majority of the metals. The first three on the list, oxygen, hydrogen, and nitrogen, are of chief importance; as embracing the constituents of water, and the main constituents of air. Sulphur deserves particularly to be studied, as the radical of the most important acid, and as an element often associated with animal and vegetable matter. Phosphorus arrests attention on many accounts, but chiefly on account of its being an invariable constituent of bone. Chlorine, iodine, and bromine constitute important medicines, both in their free state, and in various states of combination, and, by reason of their extensive range of affinity, form many interesting compounds. They are also important in the arts; chlorine in bleaching, iodine in dyeing, and both iodine and bromine in Daguerreotype processes. Very recently I have received information from an enterprising physician of western Pennsylvania, that bromine exists in large quantity in the bittern of the salt works of that region. The specimen sent me for examination proved to be of good quality. From the accounts I have received, I feel little doubt that bromine can be furnished from this locality, cheaper than it could be obtained from Europe, provided the demand for its use in medicine and the arts should justify its manufacture on any considerable scale. Carbon, or charcoal, is a very important non-metallic element, as forming an essential constituent of the atmosphere, and as being the chief ingredient of animal and vegetable substances. It is also found in considerable quantities, both in a free and combined state, in the mineral kingdom; forming great masses of coal, and entering, as a constituent, into all kinds of lime stone in the form of carbonic acid. The remaining non-metallic elements, selenium, fluorine, boron, and silicon, are comparatively of little importance.

The metals are forty-five in number, if we include *erbium* and *terbium*, two metals recently discovered by Mosander. Some of the metals form salifiable bases by combining with oxygen, and others acids. Those which form bases are distinguished into three groups, according to the nature of the base formed, whether it be an alkali, an earth, or an ordinary oxide. Many of these metals deserve the particular attention of the medical student, as furnishing a number of most important medicines. We may enumerate as of medical importance, the alkalifiable metals, potassium and sodium, the metals of the earths, calcium, magnesium, barium and aluminium, and the metals forming ordinary oxides, iron, zinc, lead, tin, copper, bismuth, mercury, silver, gold and platinum. Among the acidifiable metals, we have two, antimony and arsenic, of great importance in a medical point of view. The mere enumeration of these metals recalls to our recollection a number of preparations, indispensable in the practice of our profession. We are reminded of the salts of potassa and soda; of the preparations of lime, magnesia, and baryta; of alum; of the oxides, chloride, iodide, carbonates, and sulphate of iron; of the oxide, chloride, carbonate and sulphate of zinc; of the oxides, iodide, carbonate, and acetate of lead; of the sulphate and subacetate of copper; of the subnitrate of bismuth; of the oxides, chlorides, iodides, cyanuret, and nitrate of mercury; of the nitrate of silver; of the tartrate of antimony and potassa or tartar emetic; and, lastly, of arsenious acid and arsenite of potassa. It is not essential that the physician should be able to make these preparations, This practical knowledge is necessary only to the manufacturing chemist and apothecary. But the physician should be familiar with their appearance and qualities, their behavior with reagents, their incompatibles, the tests of their purity, and the mode of detecting minute quantities of such of them as are poisons.

After having finished inorganic bodies, we shall take up organic chemistry, embracing vegetable and animal substances. These substances are all derived directly or indirectly from living beings, whether plants or animals. This department of chemistry has sprung forward with amazing rapidity within the last ten or fifteen years, so numerous are the facts which have been brought to light by Liebig, Whöler and Sherer in Germany; by Mulder in Holland; by Dumas, Boussingault and Dènis in France; by Gregory, Playfair and Johnston in Britain; by Kane in Ireland; and by a host of other chemists, whose names are too numerous to be mentioned. In consequence of the great number of labourers in the field, the materials of this department of chemistry have accumulated much too rapidly to permit of their being arranged in systematic order and; hence the classifications which have been attempted are necessarily imperfect, and must be viewed as merely provisional. When we reflect that organic substances are chiefly composed of the four elements, nitrogen, carbon, hydrogen and oxygen, which seem capable of combining in every variety of proportion, represented by any number of their equivalents, that some of them form isomeric groups, and that many are modified by uniting with inorganic substances—it is easily perceived how extremely numerous the possible combinations and modifications must be. Great numbers of these substances have been latterly discovered, and many more are, no doubt, destined to be formed in the progress of investigation. So long as the chemist does not recognize any limit to the number of equivalents of each element which may enter into the constitution of an organic compound, the number of possible combinations is infinitely numerous; but the opinion may be ventured as highly probable, that, in the progress of science, when the organic compounds come to be better understood, formulæ which include high numbers of equivalents, will be reduced to simpler terms, without contradicting experimental results. It is, indeed, true, that sometimes an element is present in so small a proportion, that, when it is reduced to the amount of one equivalent, the other elements still require to be represented by a high number of equivalents. In cases like these, it is not easy to perceive how a formula can ever be simplified, assuming the experimental results on which it is founded to be correct.

In consequence of the difficulties attending the study of organic chemistry in its present changeful condition, I shall not attempt to teach it in detail. A sketch of the laws of combination as applied to organic substances, and a description of those which are important in a medical point of view, will be alone attempted. Such a sketch will suffice for the generality of students, and will place in the right path, those whose tastes and opportunities may lead them hearafter to pursue the subject further.

The chemist not merely studies the products of organized beings, but endeavors to trace the materials of their nutrition and growth up to their source; guided by the truth that the vital forces produce no new element, but merely combine those that pre-exist. Now the source of these materials is evidently the inorganic kingdom; for animals are ultimately nourished by vegetables, and vegetables derive the materials of their growth from the atmosphere and soil, but principally from the atmosphere. The chief elementary constituents of plants are carbon, hydrogen, and oxygen. The carbon is derived from the carbonic acid of the air, the hydrogen from its moisture, and the oxygen directly from it by absorption. The little nitrogen in plants is obtained, according to Liebig, not from the free nitrogen in the air, but from a very minute proportion of ammonia, always present in it. The mineral substances, contained in plants, and which form their ashes when burned, are derived from the soil.

The woody fibre of plants consists principally of carbon; and when we consider the immense quantities of this element which must be fixed in them, but especially in the wood of the extensive forests, which cover so large a portion of the earth, it is not easy at once to credit the assertion, that the minute proportion of carbonic acid in the atmosphere forms a sufficient source of it all. Nevertheless it must be borne in mind, that the absolute quantity of carbonic acid in the atmosphere is very considerable. Supposing, on the average, that the carbonic acid present amounts to one part in two thousand, it would form, if collected at the earth's surface, instead of being diffused throughout the whole atmosphere, a stratum between nine and ten feet thick. The assimilation of carbon by the plant is always attended with the extrication of oxygen; and the quantity of the gas evolved is exactly equal to that which would be necessary to form carbonic acid with the carbon assimilated; but whether this oxygen proceeds entirely from carbonic acid, or partly from carbonic acid and partly from water, which latter comes into play to furnish the hydrogen of woody fibre, is not yet satisfactorily determined.

Having explained, in a general way, how plants are nourished by inorganic substances, the next point of inquiry is, how are animals nourished by plants? As vegetables, as a general rule, contain but little nitrogen, and animals a considerable quantity of this element, the impression would be natural that vegetable substances are inappropriate for the nourishment of animals. But when nutritious vegetable substances are analyzed, they are found to contain certain nitrogenous principles, which are identical, in essential nature, with the principles of the blood, and, therefore, with animal matter, which is formed from blood. These same nitrogenous principles occur also in animal substances, and are denominated fibrin, albumen, and casein. They are found to be identical, so far as relates to their main constituents, nitrogen, carbon, hydrogen and oxygen, but to differ as to the mineral substances which they contain; fibrin and albumen containing minute quantities of sulphur, phosphorus and phosphate of lime; and casein, minute portions of sulphur, phosphate of lime and potassa. They are all capable, by peculiar chemical treatment, of having their mineral substances separated, and what remains is perfectly identical, whether procured from fibrin, albumen, or casein. The substance thus obtained, which forms the common basis of these three substances, is called *protein.* This memorable discovery was made by Mulder, of Amsterdam.

It may be readily comprehended how these three principles, fibrin, albumen, and casein, which are called *protein principles* from the name of their common basis, may serve to form blood, and, therefore, to nourish animals; for albumen and fibrin are the chief constituents of blood, and casein, as a protein principle, is readily converted either into fibrin or albumen. Indeed, it matters not whether the nourishment of the animal be derived from fibrin, albumen, or casein; for the protein principles, from having a common basis of protein, are readily convertible into each other.

The use of the mineral substances, contained in the protein principles, remains to be explained. The phosphate of lime, contained in them all, is obviously necessary for the formation of bone. The sulphur, also never absent, forms an essential part of most of the tissues; and phosphorus is always present in brain and nervous matter, and potassa in milk. As casein, the characteristic principle of milk, contains no free phosphorus, it is not easy to understand how young animals are fully nourished by milk; there being no known source of this element in casein, except the deoxidation of the phosphoric acid of phosphate of lime, and this deoxidation by the vital forces is not probable. The alkali soda, which is always present in the blood and bile, is derived from common salt.

Having shown the uses of the mineral constituents of the protein principles in the nourishment of animals, the question naturally arises, whence do the vegetables obtain these mineral constituents, in order to form the protein principles? It has already been mentioned that the mineral constituents of vegetables are derived from the soil. They are presented to the plant in the form of potassa and soda, of phosphoric and sulphuric acid, and of lime. All these substances are found in rocks of igneous origin, which form the basis of the crust of the earth. Potassa, indeed, is present to the extent of fourteen or fifteen per cent. in felspar, which forms four-fifths of ordinary granite ; and phosphoric acid has been detected by Fownes in porcelain clay derived from decomposed granite, and in several specimens of lava.

We have thus far spoken of three nitrogenous protein principles, fibrin, albumen, and casein, which are derived originally from vegetables, and designed for the nutrition of animals. These are called by Liebig *plastic principles of nutrition*. But it is well known that herbivorous animals consume large quantities of food, the main constituents of which are starch, gum, and sugar, in which there is no nitrogen, unless starch be admitted to contain a minute quantity. These substances cannot be fit for forming blood and flesh ; and the question arises, what part do they perform in the animal economy? Liebig answers this question by alleging that they furnish materials for oxidation, and, therefore, for the production of animal heat. As the necessary oxygen for this purpose is obtained from the air in respiration, Liebig calls these substances, *principles of respiration;* that is, principles which, during the circulation, are burned by the oxygen obtained in respiration. As starch, gum, and sugar contain hydrogen and oxygen in the proportion to form water, the hydrogen in them and like substances may be held to be already burned ; so that, in these cases, it is the remaining element carbon, which is the subject of the oxidation.

Liebig considers the blood-globules to be the chief recipients and carriers of the oxygen absorbed in respiration; and that they are enabled to do so, by means of the iron which they contain. The arterial blood, which gets its characters from the absorbed oxygen, loses this element in the capillaries, where it is converted into an equal volume of carbonic acid by the slow combustion of carbon. The blood returns in the venous state to the lungs, loaded with this carbonic acid ; and is there brought back once more to the arterial state, by the exhalation of the carbonic acid, and the absorption of an equal volume of oxygen.

Liebig has proposed a beautiful theory in explanation of these changes. He supposes that the venous blood, brought to the lungs, contains the carbonic acid, united with protoxide of iron, that, during its change there into arterial blood, the carbonate of protoxide of iron is, transformed into sesquioxide of iron, by the loss of carbonic acid, and the absorption of oxygen; and that the sesquioxide, thus formed, is, by a converse operation, implying the oxidation of carbon, brought back to the state of carbonate of protoxide in the capillaries, where the arterial becomes once more changed into venous blood.

This plausible theory is liable to several objections. In the first place, the oxygen, assumed to be derived from the sesqui oxide of iron, is already burned, as it were, by being in a state of combination with the metal. It is, therefore, not fitted for giving out more heat by its combination with carbon, in the formation of carbonic acid. Again, it has been observed by Andral, that the animal temperature is undiminished in anæmia, a disease in which the blood-globules are strikingly diminished. Now, if the blood-globules, as carriers of oxygen, are as influential in the production of animal heat, as is represented by Liebig, anemic persons should exhibit a diminished animal temperature.

Carnivorous animals derive their principles of nutrition from the flesh and blood of other animals, which consist exclusively of the protein compounds. According to Liebig, they have no occasion for the principles of respiration. The waste of their tissues, from the activity of their life, furnishes, according to him, a supply of carbon for combustion, sufficient to produce their animal heat.

Man, as an omnivorous animal, derives the principles of nutrition both from vegetable and animal sources, and comsumes, moreover, a certain amount of the principles of respiration, but much less than the herbivorous animals do. Fat and other oily substances are principles of respiration; for they contain no nitrogen, and, therefore, cannot be converted into any form of protein. They differ from the three principles of respiration, starch, gum, and sugar, already mentioned, in containing an excess of hydrogen, above the quantity necessary to form water with their oxygen. This excess of hydrogen forms a material for oxidation, additional to the carbon; and it is on this account that these fatty substances are considered by Liebig as better fitted for producing animal heat than those, like starch, gum, and sugar, which are represented in composition by carbon and water only. The well known preference evinced by the inhabitants of extremely cold countries for oily food, such as blubber, tallow, and train oil, and the fact that enormous quantities of these substances are consumed by them, go far to support Liebig's views.

Thus, gentlemen, I have presented to you an outline of the modern chemical views entertained in relation to nutrition, respiration, and animal heat. Sufficient, I trust, has been said to convince you that chemistry has done much in elucidation of these points of physiology. If time permitted, I could easily show, that many more of the healthy functions require for their explanation, the application of chemical principles. Let me ask, can the function of digestion be successfully studied without a knowledge of chemistry; or can we hope to make any solid progress in determining the nature of sanguification and secretion, without first learning from the chemist, the composition of the blood, and of the various secreted fluids?

In pathology and therapeutics, no less than in physiology, the aid derived from chemistry is manifest. By comparing the composition of the solids and fluids in the healthy and diseased states, the nature of morbid changes is often appreciated, and the appropriate remedies are suggested. It is in elucidating the pathology of the fluids, that chemistry has afforded the greatest aid. It is true that the humoral pathology fell into disrepute, and justly so, on account of the errors of its advocates, indulging, as they did, in vain speculations, instead of pursuing the sure road of observation and experiment. It is true also that, formerly, the attempt to apply chemistry to the elucidation of pathological facts, was considered as a vain endeavor to apply chemical principles, where only vital forces preside. Thanks to the progress of organic chemistry in our own times, these prejudices are fast wearing away, and the chemical investigation of the healthy and diseased fluids is no longer considered as equivalent to denying the paramount influence of the vital forces.

In illustration of the important aid afforded by chemistry to pathology and therapeutics, we shall call your attention to a few striking facts in relation to the chemical characters of the urine and blood in health and disease.

In the first place, the chemist has instructed the physician in the knowledge of the constituents of healthy urine. Taking this as our standard, the diseased conditions of the secretion are made out by analysis. The result of these investigations has been to throw diseased urine into two chief classes; one in which the phosphates predominate, the other characterized by an excess of uric acid. In the former case, the tendency is to form phosphatic deposites; in the latter, to generate uric acid gravel. When a granule of either deposite lodges in the bladder and grows by accretion, it gives rise to one of the most painful diseases to which man is liable. Now the chemical facts, thus brought to light, direct the physician in the selection of his remedies, which act moreover on chemical principles. For phosphatic deposites mineral acids must be taken; for uric acid the appropriate remedies are the alkalies, alkaline salts containing a vegetable acid, and magnesia. In the case in which oxalate of lime is prone to be deposited, no chemical remedy has yet been discovered; but by forbidding the use of acid vegetables, such as sorrel, &c., the diathesis may to a certain extent be changed, and the tendency to this deposition checked. Again, in that curious and intractable disease, diabetes, grapesugar is found in the urine; and by repeated analysis of the secretion, the progress of the disease, and the effect of remedies whether favorable or otherwise, are ascertained. In dropsy the urine often contains albumen; and its greater or less amount in different cases has an important bearing on the treatment. This morbid ingredient in the urine is detected by its giving a decided precipitate with infusion of galls, nitric acid, or corrosive sublimate. When the secretion is loaded with albumen, it will coagulate when held in a spoon over a candle.

In considering the blood, the point of departure of the chemical pathologist is its composition in the healthy state. Comparing its morbid condition, as revealed by analysis, with this standard, he is enabled to determine, with tolerable accuracy, in what the deviation from health consists, so far as this fluid is concerned. Sometimes the observed change in the blood seems to be the chief character of the disease; at other times, merely a concomitant or consequence of general diseased action. The most complete and methodical account of the diseased conditions of the blood, as determined by analysis, we owe to the recent researches of Andral and Gavarret. They analyzed the blood in several diseases, and came to a number of important conclusions, having a bearing on pathology and therapeutics. A few of these will be briefly noticed. In plethora there is an increase, in anæmia a diminution of the globules, without any material change in the proportion of the other constituents of the blood. An excess of fibrin denotes inflammation; and inflammation, of a grade sufficiently high to excite fever, never exists, without being accompanied by this peculiarity of the blood. Guided by the indications derived from the fibrin of the blood, additional proof has been afforded that accidental productions, such as tubercle, scirrhus, &c., are not of an inflammatory nature; although, in their progress, they may give rise to inflammation in surrounding parts, in the efforts of the system to eliminate them. Now the facts thus brought to light by the analysis of the blood, could never have been discovered by its mere inspection. If the appearance of the blood were our sole guide, we should be led to adopt the very erroneous supposition, that the morbid action in chlorosis and articular rheumatism is essentially the same; for the blood is buffed in both these diseases.

Enough, I trust, has been said, Gentlemen, to convince you that chemistry has an intimate connection with medical science. But it is not sufficient that you should be satisfied on this point. You may commence your chemical studies fully impressed with their importance, and with a firm determination to pursue them diligently; and yet much time may be lost, and much labor expended in vain, if your plan of study should be injudicious. Hence it may be useful before I close, that I should give you some hints as to the best method of pursuing your chemical studies.

During your attendance on chemical lectures, it is inexpedient to peruse any chemical work regularly through. Instead of attempting this, it is more useful to read upon the subjects which are brought forward by the lecturer from day to day; in order that the instruction received in the lecture room may be more fully comprehended and impressed on the memory. Before attendance on lectures, or in the interval between two courses, one or more systematic works may be read with advantage, omitting the part treating of organic chemistry. After the student feels himself well grounded in the principles of the science, it will be time enough for him to take up organic substances. At this stage of his progress, it will be proper for him to peruse Liebig's animal chemistry, and several of the best works relating to the application of chemistry to physiology and pathology. Here I particularly recommend to the attention of the student, Berzelius on the Urine, and Andral on the blood; the former work translated by Drs. Boyè and Leaming, the latter by Drs. J. F. Meigs and A. Stillé.

In conclusion, Gentlemen, I need hardly add, that it will give me great pleasure to facilitate your studies by every means in my power. I beg that you will be faithful in your attendance in the lecture room. If inexperienced in the study of a science by oral instruction, you can scarcely conceive how great a disadvantage it is, to miss even a single lecture. Recollect that chemistry forms one of the foundations of medical science, and that you cannot raise the superstructure, unless the foundation be carefully laid. Bear in mind the incentives you have to diligence. and the mortifications that await you, in case you falter in your course. Form now the resolution to begin well, and to continue faithful to the end; and if you keep your resolution, the result will be honor to yourselves and credit to your teacher.